Journal of the Andaman Science Association Vol. 27 (Special issue):22-30 (2022)
ISSN 0970-4183, Printed in India

Characterization of Wild Fagaceous Nut Species for Morphometric Traits from Sub-tropical Forest Area of Kyrdemkulai, Meghalaya

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Abstract

Nuts are rich source of phytonutrients like carbohydrate, fats, protein, vitamins and minerals. Fagaceous nuts are highly diverse and well-distributed across the globe. Diversifying fruit industry and preserving ethnic food habits are necessary for nutritional security and conservation of the species in the face of uncertainties. The basic morphometric traits of wild fagaceous nut found in the forests of Kyrdemkulai circle, Ri-Bhoi district of Meghalaya were characterized in the present study. Few wild fagaceous nuts identified with native Khasi names *viz*. *Soh-ot-saw* (*Castanopsis purpurella* (Miq.) N.P.Balakr.), *Soh-ot-rit* (*Castanopsis indica* (Roxb. ex Lindl.) A.DC), *Soh-ot-langkraw* (*Castanopsis tribuloides* (Sm.) A.DC) and *Soh-ot-dieam* (*Lithocarpus fenestratus* (Roxb.) Rehder) were characterised for morphometric parameters like nut length, diameter, nut weight, hilum length, nut colour, nut shape, burr colour, burr nature, leaf length, leaf width and leaf shape. So far, no attempts have been made to understand the extent of diversity for morphological characters and to select superior types of these species in the region. Hence the descriptions given in this manuscript will serve as a primary information for further selection and detailed characterization studies. The results of the present study revealed that *C. indica* was found to be pomologically superior with respect to nut length and nut weight than the other two studied species of the genus. Locally, the edible wild nuts of these three species are consumed fresh, sun dried and roasted. Nuts of *L. fenestratus* are not preferred for human consumption and solely eaten by wild animals.

Key words: *Characterisation, conservation, Fagaceae, Northeast India, species diversity, utilization*

Introduction

Meghalaya has rich biodiversity with a dense forest area of 17,927 km^2, but the potential of the existing flora is still under-utilized. A total of 151 species (49 families and 86 genera) of wild edible fruits used by the Khasi tribes of Meghalaya have been recorded (Jeeva, 2009). Most common underutilized edible fruit genetic resources in Meghalaya are *Padus napaulensis* (Ser. ex DC.) Schneider, *Elaeagnus latifolia* L., *Myrica esculenta* Buch.-Ham. ex D. Don, *Baccaurea ramiflora* Lour., *Pyrus pashia* Hamilton ex D. Don, *Calamus meghalayensis* (Becc.) A.J. Hend., *Gynocardia odorata* R. Br., *Prunus undulata* Buch.-Ham., *Docynia indica* (Wall.) Decne., *Rhus chinensis* Mill. and *Viburnum foetidum* Wallich (Rymbai et al., 2015; Kharshandi et al., 2015).

Indigenous fruits play a significant role in food and livelihood security of people in the developing nations (Muok et al., 2001; Deshmukh and Shinde, 2010; Mwema et al., 2012; Mabaya et al., 2014) and are reported with richer nutritional value than commercially cultivated fruits (Eromosele et al*.,* 1991; Maikhuri et al., 1994). In the recent times, the younger generations are in denial to even consume the native seasonal fruits due to dilution of traditional knowledge, change in consumption habits, negligence, ignorance and over-dominance by improved commercially-cultivated fruits in the society. Further, increase in urbanization and commercial exploitation of forests and waste lands have threatened the existence of these indigenous species (Makdoh et al., 2014). Hence, diversification in fruit industry is a necessity for addressing health and nutrition insecurity, poverty reduction, unemployment and conservation of the rare species. It is a positive sign that in the recent times, the underutilized species have gained attention by the researchers dealing with various aspects (Devi et al., 2018 a,b,c).

Nuts are important sources of protein, carbohydrate, vitamins, minerals, dietary fibre and other phytonutrients (Ros, 2010). They are genetically very diverse group and distributed throughout the world. In India, fagaceous

group of nuts (those belonging to the family Fagaceae) are found growing both in the orchards and in wild throughout the Himalayas up to Assam and Meghalaya at an altitude of 2000 to 3000 m above MSL (Pandit et al., 2013). The fagaceous nuts have been under-utilised in the country as a whole. In Meghalaya, these under-utilized nuts have tremendous potential and can be popularized for commercialization with proper value addition. Fagaceous nuts can be grown and produced under organic system in areas where other fruit crops cannot be grown (Pandit et al., 2013). Being propagated through seeds, these nut species possesses vast genetic variability and heterogeneity for important traits. Characterization and identification of superior germplasm is necessary to promote these species for commercial horticulture. Hence, the present study was conducted to identify and study the local genetic resources, their economic importance, potential utilities and preliminary pomological traits of different fagaceous nuts found in the Kyrdemkulai forest area of Meghalaya state.

Materials and methods

The study was conducted at sub-tropical forest area of Kyrdemkulai of Umsning Block, Ri-Bhoi District, Meghalaya during 2021-22. The area lies between E 91˚77'30" to E 92˚27'00" Longitude and N 25˚63'00" to N 26˚07'00" Latitude, and at a maximum elevation of 1,242 meters above sea level (Fig 1.). The district receives an annual rainfall of 1242.8 mm with temperature ranging between 9.8°C (min.) and 33°C (max.). Samples were collected through expeditious walks in the selected area with the help of local people. Plant samples were identified by matching the collected samples with authenticated vouchers at Royal Botanical Gardens, Kew gardens (Plants of the World Online, 2022), descriptions given in The Flora of British India (Hooker, 1890) and following specialised literatures and revisionary works and also taking advice from subject specialists.

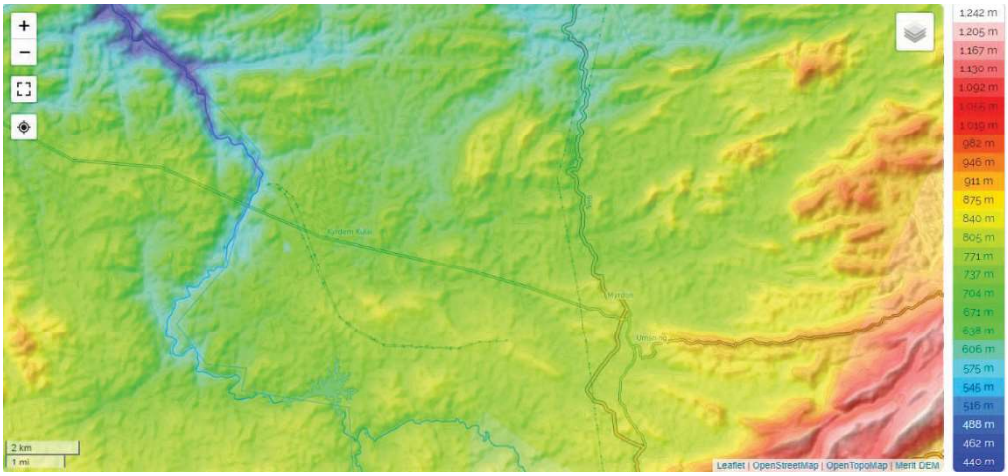

Fig. 1. Topographic map of Umsning, Ri-Bhoi, Meghalaya (https://en-in.topographic-map.com/)

Fruit samples with burr and leaves were collected from 10 trees each. The data was replicated 3 times, consisting of 10 fruits per replication. Information on local names and utilities was received from local inhabitants. The official descriptor list and guidelines of the International Union for the Protection of New Varieties of Plants (UPOV, 1989) were used to characterize the samples. Morphological parameters like nut length (mm), nut diameter (mm), nut weight (g), hilum length (mm), nut shape, nut colour, leaf length (cm), leaf width (cm), leaf symmetry, leaf colour (upper and lower), leaf shape, incision of leaf margin, bur colour and bur nature were recorded. Standard statistical parameters like arithmetic mean, standard deviation (SD) and co-efficient of variation (CV%) were calculated and standard descriptions of the qualitative characters were recorded as per UPOV (1989).

Results and discussion

Diversity and utility

During the study, four fagaceous species were identified from the sub-tropical forest area of Kyrdemkulai, Meghalaya. After comparison and referencing of the characters, the collected species were identified as *Castanopsis purpurella (*Miq.) N. P. Balakr., *Castanopsis tribuloides* (Sm.) A.DC, *Castanopsis indica* (Roxb. ex Lindl.) A.DC. and *Lithocarpus fenestratus* (Roxb.) Rehder (Plants of the World Online, Kew Science, 2022; Hooker, 1890; Singh and Singh, 2016). The vernacular names of the identified species are listed in Table 1. The species identified in this study were also listed among the 24 species of fagaceous nuts reported by Singh and Singh (2016).

Table 1. Wild fagaceous nuts found in the sub-tropical forest of Kyrdemkulai, Meghalaya

Species	Reference	Local name	Nuts Availability	Local utilities	Market
Castanopsis purpurella (Miq.) N. P. Balakr.	http://specimens.kew.org/herbarium/K000832670	*Soh-ot-saw*	November-December	Consumed raw/roasted	Local markets, Umsning, Iewduh, Bara Bazar, Shillong
Castanopsis tribuloides (Sm.) A.DC	http://specimens.kew.org/herbarium/K000832662	*Soh-ot-rit*	November-December		
Castanopsis indica (Roxb. ex Lindl.) A.DC.	http://specimens.kew.org/herbarium/K000832671	*Soh-ot-langkraw*	November-December		
Lithocarpus fenestratus (Roxb.) Rehder	http://n2t.net/ark:/65665/3d33d97ce-0efb-432c-8df3-fb9682081df8	*Soh-ot-dieam*	August-November	Not consumed; eaten by wild animals	

With respect to their consumption pattern, the rural people of the region collected the nuts from the wild forest and consumed raw or roasted, except *L. fenestratus*. Similar consumption pattern was also reported by Dangol et al. (2017). The local harvesters also sold the collected nuts at regional markets like Umsning, Iewduh, Bara Bazar, Shillong (Makdoh et al., 2014; Singh and Singh, 2016). The village residents of the area did not utilise these nut trees for other purposes. However, there are reports of leaves of fagaceous nuts being used for treating stomach disorders, skin infection (Singh and Singh, 2016), bark extracts for anti-cancer and antipyretic activity (Hasan et al., 2022), bark paste for controlling chest pain, curing snake bites (Joshi et al., 2011) *etc*. Other utilities included fodder leaves, firewood and timber (Pokharel et al., 2021; Aye et al., 2012).

Nut length

Among the selected four fagaceous species, the average nut length of *C. indica* was the highest (19.86 mm) followed by *C. purpurella* (15.34 mm) (Table 2). The least average nut length was registered by *C. tribuloides* (12.01 mm). The observations on nut length of the studied species were in line with the studies by Aye et al. (2012) and Pokharel et al. (2022). Meanwhile, Solar et al. (2005) and Poljak et al. (2021, 2022) reported higher mean nut length of European chestnut and sweet chestnut (27 mm).

Nut diameter

L. fensetratus exhibited maximum average nut diameter (15.71 mm), which was closely followed by *C. purpurella* (15.30 mm) (Fig. 2). Like nut length, the lowest values for nut width (11.05 mm) was also observed in *C. tribuloides*. The observed values were in accordance with the report given by Pokharel et al. (2021) in *C. tribuloides*, *C. indica* and *L. fenestratus,* although Aye et al. (2012) reported larger diameter of *C. indica* nuts (30 mm). The nut size of the species is intermediary when referred to *Castanea sativa*, with reported mean diameter range of 12 to 35 mm (Solar et al., 2005; Poljak et al., 2022).

Nut weight

Among the studied species, *C. indica* was recorded with the maximum nut weight (4.89 g). Nuts of *C. tribuloides* and *L. fenestratus* were observed to be comparatively lighter i.e. 3.10 g and 3.08 g, respectively (Table 2, Fig. 2). The values are in accordance with the earlier report (Chou et al., 2011). The nut masses are much lighter than the well-known chestnuts (*C. sativa*) values for which have been reported to be in the range of 5.23 g to 16.37 g (Kim et al., 2005; Solar et al., 2005; Pandit et al., 2013; Poljak et al., 2022).

Hilum length

The present study revealed that nuts of *C. purpurella* had the maximum mean hilum length (14.49 mm), followed by *L. fenestratus* (11.94 mm), *C. tribuloides* (8.87 mm) and *C. indica* (7.90 mm) (Table 2). Studies by Solar et al. (2005) and Poljak et al. (2022) have reported mean hilum length of *C. sativa* to be 22 mm. Higher values for hilum length in common chestnut (*Castanea sativa*) are indicative of its morphological difference from the wild fagaceous nuts.

Nut shape

Nuts of both *C. purpurella* and *C. tribuloides* were broad ovoid-globose, while nuts of *C. indica* were ovoid and those of *L. fenestratus* were globose (Table 3, Fig. 2). Aye et al. (2012) have also reported ovoid shape in *C. indica* and globose in *L. fenestratus.* However, Pokharel et al. (2022) described their observations on the *C. hystrix, C. tribuloides* and *C. indica* as broadly conical, although the referencing of characterisation has not been stated.

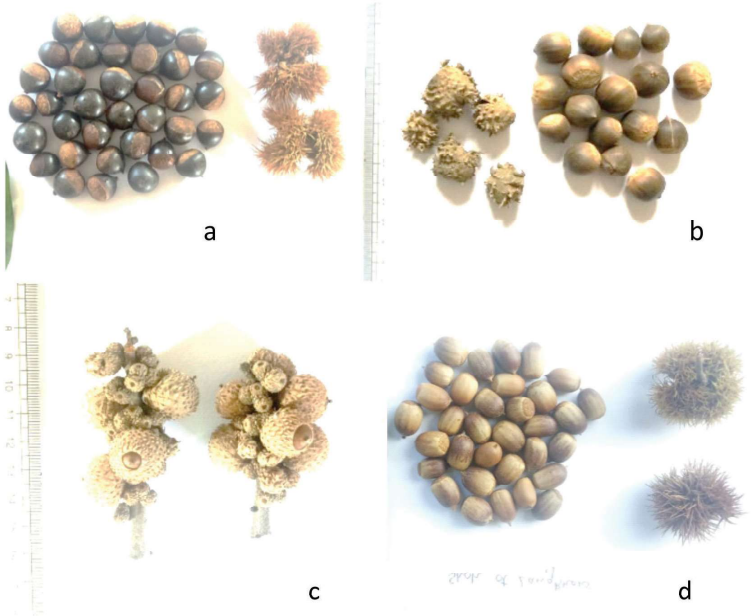

Fig. 2. Fruit and bur of wild fagaceous nuts found in the sub-tropical forest of Kyrdemkulai, Meghalaya: (a) *Castanopsis purpurella* (b) *Castanopsis tribuloides* (c) *Lithocarpus fenestratus* (d) *Castanopsis indica*

Nut colour

The nut colour, as described in UPOV (1989) guidelines *viz*. light brown, brown, dark brown, reddish brown and blackish brown, was recorded in the studied species. While it was blackish brown in *C. purpurella*, nuts of *C. tribuloides, C. indica and L. fenestratus* were brown, light brown-brown and reddish brown with raised stripes, respectively (Table 3, Fig. 2). The result also revealed *C. indica* with the lightest and *C. purpurella* with the deepest hue. In a study by Solar et al. (2005), *C. sativa* was reported to be of intermediate hue, slightly deeper but in closer proximity with that of *C. tribuloides.* Similar observations were also reported by Aye et al. (2012). However, Poljak et al. (2021) showed reddish brown colour in traditional sweet chestnut varieties and reddish brown-dark brown in hybrid chestnuts.

Leaf characteristics

Standard characters like leaf length (cm), leaf width (cm), leaf symmetry, leaf colour (upper and lower), leaf shape and incision of leaf margin were studied as per UPOV (1989). These four species have different foliage shapes and sizes. Among the studied species, *C. indica* was recorded with largest leaf dimension of 21.64 cm length and 9.96 cm width. Leaves of other three species were reported to have mean leaf length and width of 11.20 cm × 4.22 cm, 13.84 cm × 5.72 cm and 16.40 cm × 4.46 cm for *C. purpurella, C. tribuloides and L. fenestratus*, respectively, indicating *C. purpurella* to have shorter and narrower leaves (Table 2, Fig. 3). *C. indica* was observed to have distinctly larger leaf size and sharp incision on the edges (Fig. 3). The leaf sizes are in accordance with the observations presented by Pokharel et al. (2021).

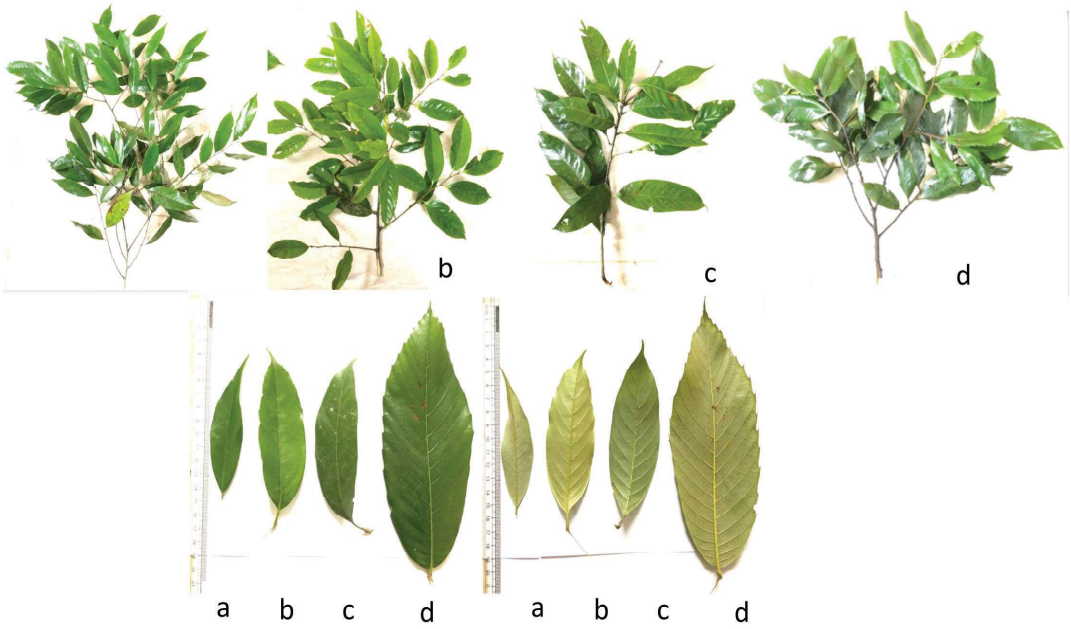

Fig. 3. Branch and leaf of wild fagaceous nuts found in the sub-tropical forest of Kyrdemkulai, Meghalaya (L-R): (a) *Castanopsis purpurella* (b) *Castanopsis tribuloides* (c) *Lithocarpus fenestratus* (d) *Castanopsis indica*

The studied species also varied in the shapes of leaf bases. Leaf base was acute in *C. purpurella*, obtuse in *C. tribuloides and L. fenestratus* and cordate in caser of *C. indica* (Table 3). Further, leaf margins were smooth in case of *C. purpurella* and *L. fenestratus*. Leaves of *C. indica* had mucronate margins, while leaves of *C. tribuloides* were mucronate only from the middle of the leaf to the apical region (Fig. 3). Similar description was also given in the Flora of British India (Hooker, 1890) and Pokharel et al. (2021).

Table 2. Morphometric traits of wild fagaceous nuts found in the sub-tropical forest of Kyrdemkulai, Meghalaya

Traits		Wild fagaceous nuts			
		Castanopsis purpurella	*Castanopsis tribuloides*	*Castanopsis indica*	*Lithocarpus fenestratus*
Nut length (mm)	Mean±SD	15.34±1.16	12.01±2.98	19.86±0.78	12.79±3.56
	Min	14.8	10.33	19.03	11.27
	Max	16.1	13.40	20.40	14.57
	CV (%)	7.56	24.85	3.93	27.82
Nut diameter (mm)	Mean±SD	15.30±1.66	11.05±2.66	14.73±1.57	15.71±0.75
	Min	14.8	10.07	13.07	14.13
	Max	15.77	12.20	15.90	16.40
	CV (%)	10.82	24.06	10.67	4.81
Nut weight (g)	Mean±SD	3.82±0.99	3.10±0.44	4.89±0.70	3.08±0.62
	Min	3.47	2.27	4.03	2.23
	Max	4.13	3.57	5.60	3.80
	CV (%)	25.85	14.06	14.35	20.28
Hilum length (mm)	Mean±SD	14.49±3.65	8.87±0.85	7.90±0.93	11.94±1.52
	Min	13.13	8.03	7.03	11.03
	Max	16.00	9.47	8.83	13.23
	CV (%)	25.20	9.59	11.77	12.71
Leaf length (cm)	Mean±SD	11.20±3.10	13.84±0.90	21.64±3.30	16.40±3.53
	Min	8.17	11.00	18.40	13.60
	Max	11.93	15.23	23.67	18.23
	CV (%)	27.71	6.50	15.27	21.16
Leaf width (cm)	Mean±SD	4.22±0.71	5.72±0.40	9.96±0.78	4.46±1.03
	Min	3.00	4.77	9.03	3.53
	Max	4.87	6.90	11.43	5.67
	CV (%)	16.80	7.07	7.80	23.03

Bur colour and nature

The cupule with the tremendous diversity of scales and spines are the most interested diagnostic characters for individual species (Aye et al., 2012). Observations on mature bur colour were also recorded as per the descriptors (UPOV, 1989). The results revealed bur hues to be reddish brown in *C. purpurella*, brown to dark brown in *C. tribuloides,* brown in *C. indica* and light brown in *L. fenestratus* (Fig. 2). With respect to bur spines, *C. purpurella* and *C. indica* were observed to have sharp

pricky spines. Aye et al. (2012) had also reported sharp spines in various species of the genus *Castanopsis*. *C. tribuloides* had blunt reduced spines in the bur (Table 3). Pokharel et al. (2021) has also described similar features from the species in Nepal. *L. fenestratus* bur had no spine and took an appearance of a scale rather than bur, which did not split easily on maturity unlike the other fagaceous nuts. Cupules of *L. fenestratus* have been recorded to enclose the nut with many curled hook-like scales (Aye et al., 2012).

Table 3. Standard descriptions of the studied fagaceous nut species

Major Details	Name of Descriptor	Wild fagaceous nuts			
		Castanopsis purpurella	***Castanopsis tribuloides***	***Castanopsis indica***	***Lithocarpus fenestratus***
UPOV No. 31	Nut shape	Globose	Globose	Ovoid (broadly conical)	Globose
UPOV No. 35	Nut colour	Blackish brown	Brown	Light brown-brown	Reddish brown
UPOV No. 16	Fully developed leaf: symmetry	Symmetric	Clearly asymmetric	Slightly asymmetric	Symmetric
UPOV No. 19	Fully developed leaf: green colour of upper side	Medium	Medium	Dark	Medium
UPOV No. 20	Fully developed leaf: colour of lower side	Light green	Light green	Light green	Light green
UPOV No. 21	Fully developed leaf: shape of base of blade	Acute	Obtuse	Cordate	Obtuse
UPOV No. 22	Fully developed leaf: incisions of margin	Absent	Mucronate (towards the leaf apex only)	Mucronate	Absent
This study	Bur colour	Reddish brown	Brown-dark brown	Brown	Light brown
This study	Bur nature	Sharp spine	Blunt, reduced spine	Sharp spine	No spine, bur resembles scale

Conclusion

This is the first characterisation study of fagaceous nuts conducted in the state. The present study revealed the variability of the fagaceous nut available in the selected region. The present study suggests superiority in traits of *Castanopsis indica*, especially with respect to nut weight and size. Alternative utilities and traditional knowledge need to be explored for increasing the value of these local nuts. Also, usage of *L. fenestratus* nuts need to be explored since the species is completely underutilized. The data can serve as preliminary information for further studies like selection of the desirable types based on biochemical,

physiological and molecular characterisation and their utilization in a sustainable manner. Such efforts would help to achieve food and nutrition security by making food basket more diverse and to achieve sustainable development based on the use of available genetic wealth, promotion and also conservation of these species.

Acknowledgments

The authors extend their sincere gratitude towards Central Agricultural University, Imphal, Manipur for facilitating basic infrastructure support for carrying out this study. Also, appreciation is due towards the Kyrdemkulai localities for the valuable information and kind co-operation while conducting the survey and collection.

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Received: 1st September, 2022 **Accepted: 14th December, 2022**